# PATENT SPECIFICATION

DRAWINGS ATTACHED

**855,495**

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COMPLETE SPECIFICATION

## Improvements in Die Casting Machines

I, WALTER MILTON GOLDHAMER, a citizen of the United States of America, of 2918, Huntington Road, Shaker Heights, State of Ohio, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to die casting operations and apparatus therefor, and has for its object the provision of an improved die casting machine of the type in which the die cavity is either vented to the atmosphere or operated under reduced pressure prior to and during the injection of molten metal. The invention provides means for removing the gas from the die cavity or mold, including the small amount of residual gas which is concentrated or compressed by the advancing metal forced into the die cavity.

In die casting, the presence of entrapped gas such as air in the die cavity restrains the flow of the metal into the die cavity causing defects in the contour of the casting, blow holes or porosity. When the injection pressure exceeds, for example, one thousand pounds per square inch, the entrapped gas is compressed and dispersed into the casting. Many proposals have been made and devices have been used to remove the gas from the die cavity by venting to the atmosphere or by the application of vacuum but these have not been entirely satisfactory because of the inability heretofore to remove the residual gas from the die cavity in a practical and economical manner.

The invention provides a passageway in the die casting apparatus connecting the die cavity with a vent to the atmosphere or to a vacuum system for evacuating the die cavity while the metal is entering the die cavity and, after filling it, entering the passageway, and means for freezing the metal in the passageway after all the gas has been removed from the die cavity, thereby entirely filling the die cavity without objectionable flow of metal through the passageway. The passageway connecting the die cavity to the vent or vacuum system is provided with cooling means to solidify the metal therein and serve as a chill plug to prevent the flow of metal from the die cavity after removal of all the gas.

The die casting apparatus comprises complementary die members which, during casting, are connected together to form, as near as is practically possible, a gas-tight cavity for the die casting, and, after casting, separated to remove the casting, at least one of the members being movable into engagement with and away from the other die member, means for injecting molten metal into the die cavity, a metal-cooling member attached to each die member, a continuous passageway formed between the die members and the metal cooling members which connects the die cavity to a vent of a vacuum source. The cooling members are preferably thermally insulated from the die members to suppress the flow of heat into the cooling members. The passageway consists of two parts, one part between the die members which is at a relatively high temperature and is larger than the other part of the passageway which is between the cooling members, thereby providing a single passageway operated at two different rates of metal flow and two different temperatures. This assures that the metal will flow readily and freely into the die cavity and fill it completely and accurately before the casting solidifies, yet permitting the gas to be vented and the metal to solidify in the part of the passageway within the cooling members and prevent its escape or passage into the vacuum system. By carrying the first portion of the incoming casting metal through and out of the die cavity at a rapid rate a more homogeneous and uniform temperature of the metal of the casting is obtained.

In an effective embodiment of apparatus

the die members, preferably of conventional construction, are rigidly and securely connected to and thermally insulated from the cooling members which include chill blocks in heat exchange contact with a coolant medium and between which the passageway is formed for the rapid solidification of the metal. The cooling members are preferably each connected to a die member and one is movable with the movable die member. The passageway portion between the chill blocks is preferably of serpentine or undulating form to provide a large cooling area in a small space, and is proportioned in cross-sectional area to effect a rapid removal of gas without an excessive loss of metal. The frozen metal in the passageway seals off the vent or vacuum line, thereby eliminating mechanically operated valves, plungers and like means for this purpose.

The part of the passageway between the chill blocks may vary from 0.020 to 0.050 inch in thickness, and the part between the die members is thicker up to, say, about ⅛th inch in thickness. The dimensioning of the passageway is important to effect a rapid removal of the gas and also a rapid solidifying of the metal in the passageway.

The apparatus of the invention makes it possible to remove in one piece the casting and the connected metal which solidified in the passageway, thereby clearing the passageway for the next cycle at the time of removing the casting.

In another aspect of the invention a second passageway as aforementioned is provided for connection to a pressure measuring or recording device to permit continuous measurement of the die cavity pressure throughout the casting cycle. This passageway is preferably connected to the opposite side of the die cavity from the aforementioned passageway which vents the cavity. This arrangement enables one to register or to record simultaneously both the die cavity vacuum level and the pressure in the cylinder which drives the metal injection piston. This eliminates the possibility of the instrument's merely measuring the vacuum level in the vacuum system without regard to the restrictions imposed by the passages into the die cavity.

One of the difficult problems in vacuum die casting is the rapid evacuation of the die cavity and the rapid injection of the metal. Due to unavoidable re-entrant air from leaks around the die members, pins, and the like, as well as the residual gas which becomes appreciable as the metal compresses it, it is important not only to remove this gas but also to record the amount of its pressure.

These and other novel features of the invention will be better understood after considering the following discussion taken in conjunction with the accompanying drawings, in which:—

Figure 1 is a side elevational view of a conventional die casting machine in horizontal arrangement embodying the invention;

Figure 2 is a plan view of the cooling members in connection with die members of the machine of Figure 1, in closed position;

Figure 3 is a side elevational view of Figure 2;

Figure 4 is a sectional enlargement of the lower part of Figure 2;

Figure 5 is an enlarged sectional view at 5—5 of Figure 2;

Figure 6 is a perspective view of the two cooling members of Figures 1 to 5;

Figure 7 is a sectional side view of a portion of the apparatus of Figure 1 for injecting the molten metal into the die cavity, shown at the beginning of the injection stroke;

Figure 8 is a view similar to Figure 7 at the end of the injection stroke;

Figure 9 is a view similar to Figure 7 when one die member has been opened for removal of the casting;

Figures 10 and 11 are cross sections at 10—10 of Figure 7 showing the two positions of the injection piston; and

Figure 12 is a vertical front view taken facing one of the die members of a modification.

The apparatus illustrated in the drawings and particularly as shown in Figure 1 comprises a die casting machine having a base 1, upright frame members 2 and 3, tie bars 4 and 5 interconnecting the frame members, a die member 6 securely connected to member 3 which has a mating complementary die member 7. The bars 4 and 5 are cross-connected by a carriage 8 which is slidable thereon and to which the die block 7 is connected by bracket 12. Carriage 8 is connected by linkage 13 to rod 14 which is operated by a piston in the cylinder 15 to open and close the die member 7.

The die blocks 6 and 7 are machined to effect tight engagement and have a die cavity 16 therebetween which connects by an upright inlet 17 leading to the cylinder 18 for the injection of molten metal. For convenience of illustration only one die cavity is shown, but it is to be understood that two or more interconnected cavities may be used in the die members. The cylinder 18 is connected to a pipe 20 which is immersed in the molten metal, for example, aluminium alloys, in reservoir 21. The assembly of apparatus 22 for injecting the molten metal into the die cavity will be described hereinafter.

The die blocks 6 and 7 each carry a securely attached cooling member 24 and 25 respectively. Between the die members and chill blocks a continuous vent or evacuation passageway is provided consisting of part 26 between the die members which is relatively thick varying from 1/16th to 3/16th inch, and part 27 between the cooling members

which is relatively thin varying from 0.020 to 0.050 inch in thickness based upon the cavity volume to be evacuated. The pipe 28 as shown connects the passageway through restricting orifice 30, solenoid valve 31 to the vacuum reservoir 32. When the apparatus is not used for vacuum casting, the pipe 28 is eliminated and the passage 27 vents directly to the atmosphere. The valve 31 is connected by line 33 to an electric switch 34 on the die members 6 and 7 so that the valve 31 is closed when die member 7 is open and is opened to apply vacuum to passageway 27 when the die member 7 is closed. The orifice is a limiting means to restrict the vacuum at the initial stage. (The valve 31, line 33 and switch 34 may be omitted if desired). Solenoid valve 35 by-passes valve 31 by pipe 36 and is connected by electric line 37 to the electrically-operated timer control T. The operation of the valves and switches will be described hereinafter. Cooling members 24 and 25 are connected by bolts B to the die members 6 and 7 and are accordingly in rigid secured attachment thereto so that the cooling member 24 remains in stationary fixed position with die member 6 and cooling member 25 is moved to the open and closed positions with die member 7. With particular reference to Figure 5 it will be noted that the cooling members engage the die members on narrow projections or lands 40 which provide air spaces 41 between the members to serve as thermal insulation and suppress the flow of heat from the die members into the cooling members. The cooling members are each formed of two main parts, nest blocks 42 and 43 formed of a metal such as stainless steel or refractory sintered metal compounds or other low heat conducting material. In the mating face of block 43 a U-shaped groove 44 is provided for the insertion therein of a gas-sealing gasket 45, such as neoprene, silicone, or Teflon (Registered Trade Mark). Each of the nest blocks has a hollow center within which is inserted chill blocks 46 and 47. These chill blocks have a series of channels C on their back surfaces for the circulation therein of coolant fluid passed into the channels through pipes P and discharged from the channels through pipes $P^1$. The chill plugs are preferably formed of metal of high heat conductivity such as molybdenum or copper. The chill plugs have corrugated surfaces 48 and 49 which when the chill blocks are in assembled position as shown in Figure 5 form the tortuous passageway 27*a* as a part of passageway 27. This undulating passageway extends from the recess in the lower end of the chill block 46 to a chamber 50 formed in the member 25 as shown in Figure 5. The nest block 42 has a projecting baffle 52 extending into the space 50 and also a space 53 contiguous with the space 50 which connects to the vacuum pipe 28. The space 53 contains a loose filtering material such as steel wool 54 which together with the baffle prevent the passage of small pieces of metal into the vacuum system. In order to facilitate the removal of the metal that solidifies in the passageway 27 the edges 55 of the corrugations are beveled. As shown in Figures 4 and 6, an ejector pin 56 having a projecting head 57 may be inserted in an opening through the nest block and the chill block and has an exterior extension which strikes the frame of the machine when the mold is opened. When the die member 7 and its cooling member 25 are opened the injector head 57 strikes against the metal in the passageway 27 and effects its removal.

If it is desired to measure or record the pressure in the die cavity, additional chill blocks 38 and 39 are connected to the die members 6 and 7, respectively, to provide a passageway $39^1$ connected to the die cavity 16 as is the passage 26 and 27. This passageway is connected to a pressure measuring device 29 which may be a gauge or a recording pressure measuring device to register or record the pressure in the die cavity during casting. This passageway is connected to the die cavity at a place remote from the passageway 26 and permits measuring the actual pressure in the die cavity 16. An alternative arrangement is shown in Figure 12.

The apparatus 22 shown in detail in Figures 7—11 is for the controlled injection of measured quantities of molten metal into the die cavity 16. This apparatus comprises a cylinder 18 secured to the die member 6 which opens into the duct 17 leading directly into the die cavity 16. The metal suction pipe 20 formed of a metal or ceramic material which is not reactive with the metal to be cast connects the cylinder 18 with the pool of molten metal in the receptacle 21.

As best shown in Figures 7 to 11, the injection piston 58 is reciprocated in the cylinder 18 by the rod 59. This piston has a groove or pocket 60 in its forward end and a longitudinal groove 61 in its cylindrical surface which extends forward only to the point 62, the functions of which will be described hereinafter. The rod 59 which drives the piston 58 has a head 64 in secured but rotatable connection with the sleeve 65. This sleeve also effects a threaded connection with the piston rod 66 of the piston operated in the cylinder 67. A locking nut 68 secures the collar to both head 64 and rod 66. The cylinder 67 is mounted on a frame 69 and is rigidly attached to the upright frame 3 by two tie rods 72 and 73. The rod 66 is sealed where it passes through the frame 69 with a stuffing gland 74. The piston operable in cylinder 67 is not shown but is understood to be an hydraulically operated piston for driving rods 66, 59 and the piston 58 in

response to the cyclic control means for the machine.

The head 64 has a transverse slot 63 in which the lever arm 75 is inserted. This lever arm has a slot 76 in which the pin 77 is inserted for oscillating the shaft 59 and piston 58. As best shown in Figure 10, a bracket 78 is secured to the rod 72. This bracket supports a cylinder 80 having therein an hydraulically operated piston (not shown) which moves the rod 81 and its attached pin 77 backward and forward to turn the lever 75. It will be noted with reference to Figures 7 and 8 that the bracket 78 is stationary and remains in secured attachment to the rod 72. The lever 75 engages the pin 77 only when the piston 58 is at the rearward end of its stroke as shown in Figure 7. The piston in cylinder 80 is operated hydraulically by fluid admitted thereto by the solenoid valve 82. This valve is actuated by the timer T of the casting machine through an electrical circuit connected with line 83. The piston of cylinder 80 is advanced at the end of each machine cycle to turn piston 58 to the position shown in Figures 7 and 10, and is retracted at the end of the low level evacuation of the die cavity to turn the piston 58 to the position shown in Figures 8 and 11.

The piston in cylinder 15 and the piston in cylinder 67 are operated hydraulically by valve means controlled from the timer T of the casting machine.

The casting apparatus of the invention is operated as follows:— When the central timer T is set for operation, the piston in cylinder 15 forces the carriage 8 and the die member 7 with its attached cooling member 25 to the closed position shown in Figures 1, 5, 7 and 8. At this time the switch 34 is closed and the valve 31 is open causing a limited vacuum, due to the orifice 30, to be created in the passageways 26 and 27, die cavity 16, duct 17 and cylinder 18. At this time, the lever 75 has turned the piston 58 to the position shown in Figures 7 and 10 and a charge of molten metal is sucked upwardly through pipe 20 from the reservoir 21 into the cylinder 18. A short interval thereafter based on the volume of the metal required, the timer T operates sequentially the piston in cylinder 80, the solenoid valve 35 and the piston in cylinder 67. The piston in cylinder 80 turns the lever 75 from the position shown in Figure 10 to the position shown in Figure 11 thereby completely disconnecting the forward portion of cylinder 18 from pipe 20. This movement sets the groove 61 over the passage in pipe 20, connecting it to the atmosphere causing the molten metal in contact with piston 58 to return immediately to the vessel 21, thereby preventing this metal from freezing in contact with the piston. At the conclusion of the setting of piston 58, the solenoid valve 35 is opened to apply full vacuum and then the piston in cylinder 67 forces the rods 66 and 59 and piston 58 forward on the injection stroke and the metal in cylinder 18 is forced through the passage 17 and upwardly into the die cavity 16. During this motion and while the full vacuum is applied the metal is entering and filling die cavity 16 and ultimately passes upwardly and with considerable rapidity through the relatively large passageway part 26 and then into the relatively narrow passageway part 27 which is within the cooling member 24 and 25. As a result of the conjoint action of the advancing metal and the vacuum all of the gases contained in the die cavity are removed. A low vacuum as generally used in this art will remove most of the gas from the die cavity. However, when a small amount of residual gas, mostly infiltrated air, is concentrated by the advancing metal it becomes a contaminant for the metal and results in casting defects and rejects. My improved apparatus removes this residual gas by forcing it into the vacuum system and then freezing the metal in the vent to serve as a plug.

Any small particles of solid metal that may have been retained in the passageways 26 and 27 are blown against the baffle 52 and are trapped by the fibrous metal 54 and thereby prevented from entering the vacuum system. As a result of the low temperature of the chill blocks 46 and 47 the metal in the passageway part 27 is completely solidified before it reaches the chamber 50.

At the completion of this operation the casting machine timer T closes valve 35, reverses the piston in cylinder 15 to move the carriage 8 and the attached die member 7 and cooling member 25 towards the left as viewed in Figure 1 to open the mold and permit removal of the die casting. Coincident with this movement the ejector part 55 strikes a lug (not shown) on the machine frame and the extreme end 57 thereof which enters the passageway 27 engages an edge portion of the metal web therein and kicks it loose. As a consequence the entire mass of solidified metal and the metal web of the passageway is removed in a single piece.

Figure 12 illustrates a modification of the apparatus of Figure 1 and is a side view at the inner face of the die member 7 showing the mounting of the cooling member 25 and a second cooling member $25^1$. This cooling member has a complementary cooling member (not shown) similar to member 24 on die member 6, which forms the passageway $27^1$ to which the gauge or recording device 29 is attached. It will be noted that the passage $26^1$ enters the cavity 16 at a position opposite the outlet passage 26. This permits the pressure in the die cavity to be measured independently of the pressure in the vacuum system and especially in passageway 26.

WHAT I CLAIM IS:—

1. In a die casting machine including complementary die members which can be connected together to form a die cavity and separated to remove the casting, at least one of the die members being movable into engagement with and away from the other die member, means for injecting molten metal under pressure into the die cavity, a separate metal cooling member secured to each die member, means for suppressing the flow of heat from the die members into the metal cooling members, at least one of said metal cooling members being movable into engagement with and away from the other metal cooling member during movement of the die member to which it is secured, a passageway between the engaged metal cooling members connected to a vent to the atmosphere or to a vacuum duct and extending into the die cavity, and means for cooling the metal cooling members to solidify metal in said passageway before the metal solidifies in the die cavity.

2. A die casting machine as defined in Claim 1 which comprises a die member and a metal cooling member connected together and movable as a unit to open and close both the die cavity and the passageway simultaneously whereby the casting and the attached metal from the passageway may be removed as a unit.

3. A die casting machine as defined in Claim 1 which comprises metal cooling members each having a chill block which engages the other chill block and between which a part of the passageway is formed, said chill blocks being formed of a metal of high heat conductivity and having means for the circulation thereon of a coolant liquid.

4. A die casting machine as defined in Claim 1 in which the passageway between the chill blocks is thin with reference to its width and is undulating to provide a long travel for the metal in a short space.

5. A die casting machine as defined in Claim 1 which comprises cooling members having chill block inserts formed of metal having high heat conductivity.

6. A die casting machine as defined in Claims 1, 2, 3 and 5 in which part of the passageway is between the cooling members and part between the die members, the part between the die members being much thicker than the part between the cooling members.

7. A die casting machine as defined in the preceding claims which comprises electrical switch means operated with the movable die member and an electrically operated valve in the vacuum duct for evacuating the passageway and die cavity when the die member is in closed position.

8. A die casting machine as defined in Claim 7 which comprises a second electrically operated valve in a by-pass of the vacuum duct which is opened by a timer to effect a lower vacuum after the first-mentioned electrically operated valve is opened.

9. A die casting machine as defined in Claims 1 to 8 in which the passageway betwen the die members is from 1/16th to 3/16th inch in thickness and the passageway between the cooling members is from 0.02 to 0.05 inch in thickness.

10. A die casting machine as defined in Claims 7 or 8 in which the vacuum duct has a restricting orifice to vary the amount of the vacuum.

11. A die casting machine as defined in Claims 1 to 10 in which the cooling members have heat exchange channels therein for the circulation of a coolant liquid.

12. A die casting machine as defined in Claims 1 to 11 in which the means for suppressing the flow of heat from the die members into the cooling members is an air space.

13. A die casting machine as defined in Claims 1 to 8 in which there is a second passageway connected to the die cavity, and means are connected to the second passageway to measure the pressure in the die cavity during the filling of the die cavity with metal.

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Agents for the Applicants.

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FIG. 1

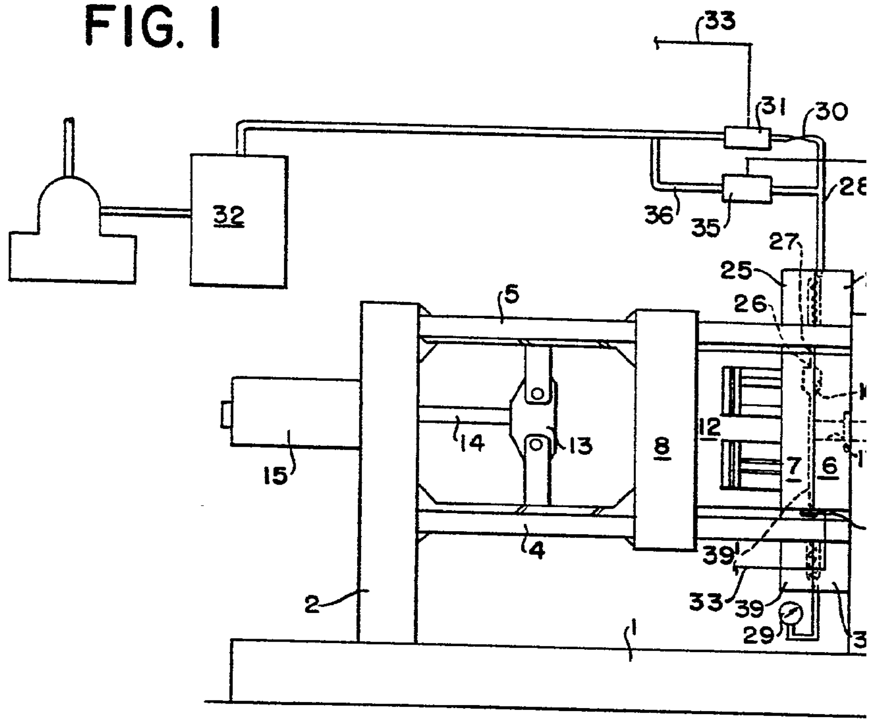
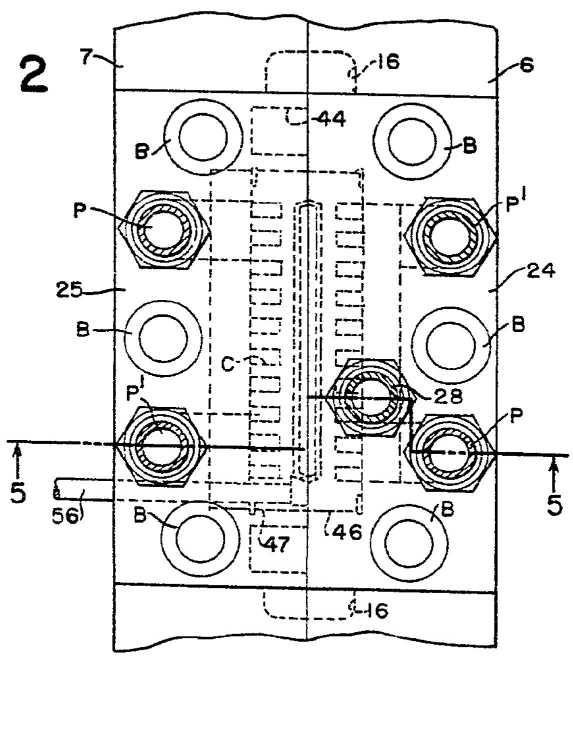
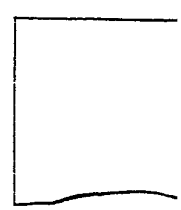


FIG. 2



FIG



855,495 COMPLETE SPECIFICATION

3 SHEETS

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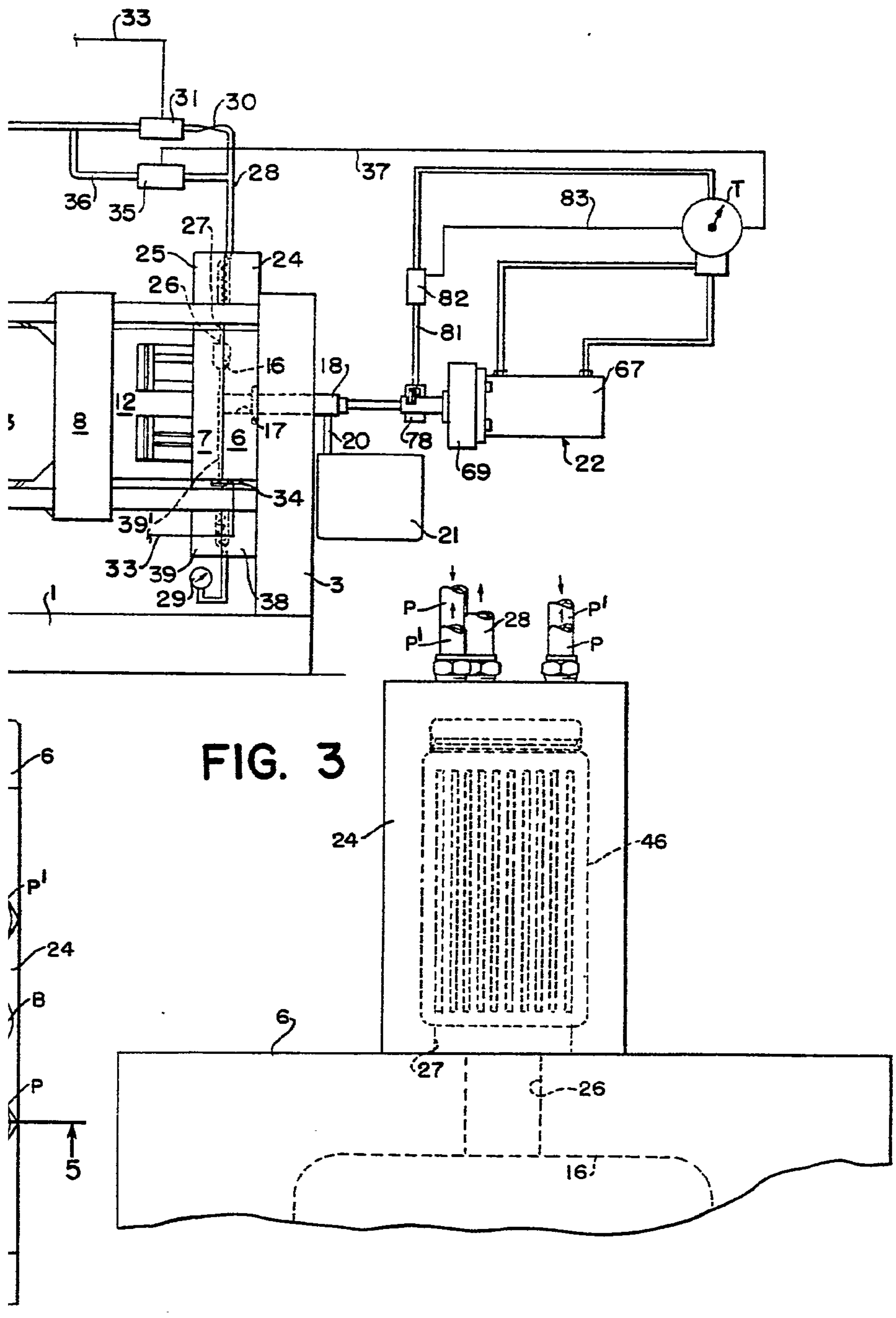
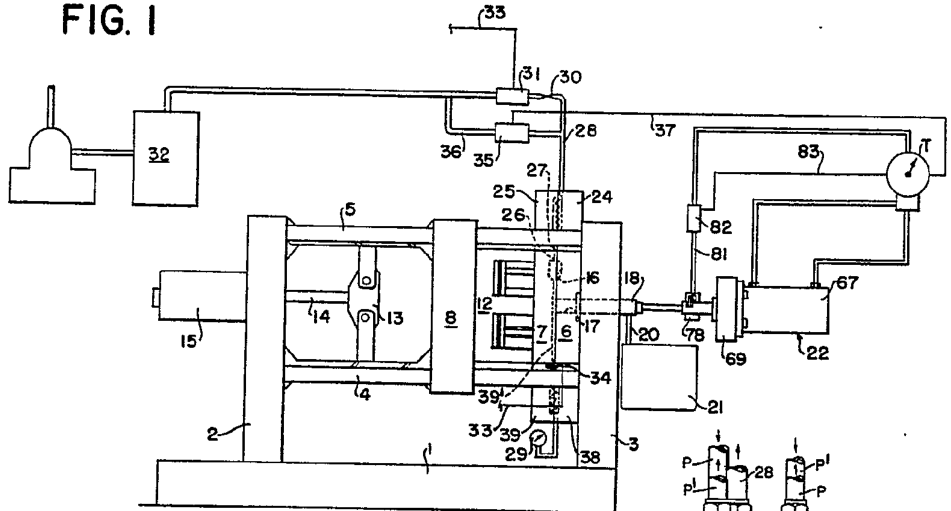


FIG. 1

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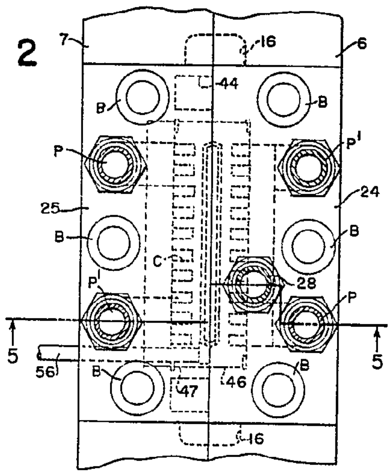
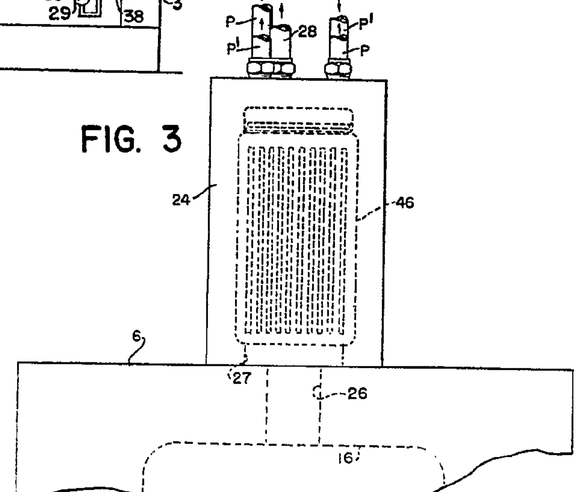



FIG. 3



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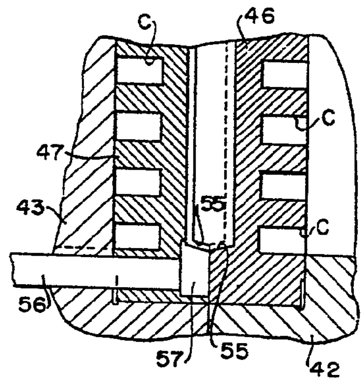
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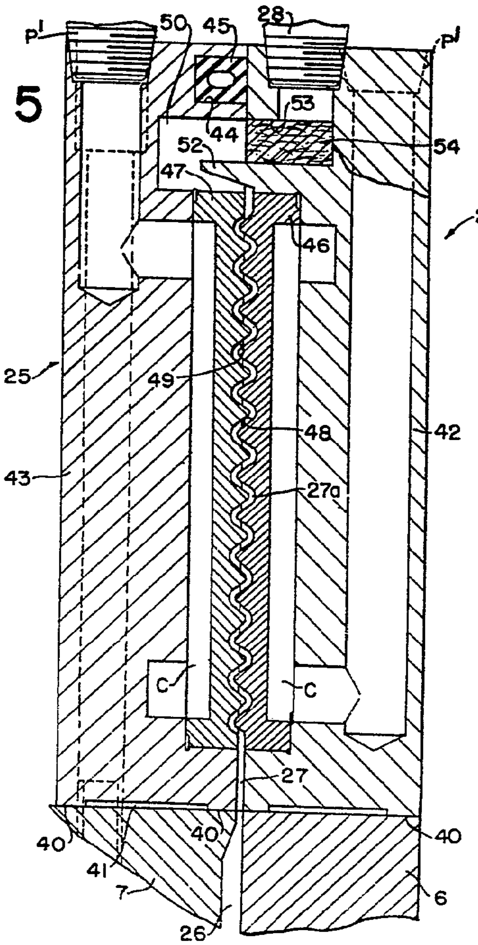
FIG. 5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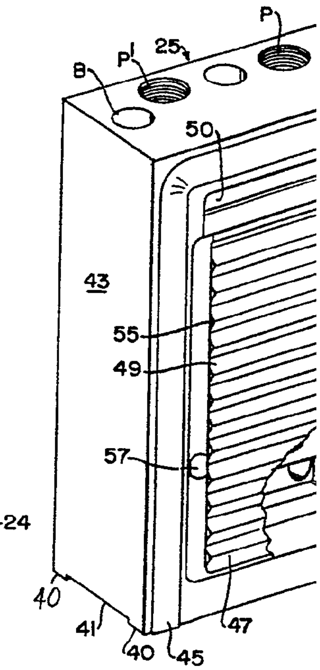
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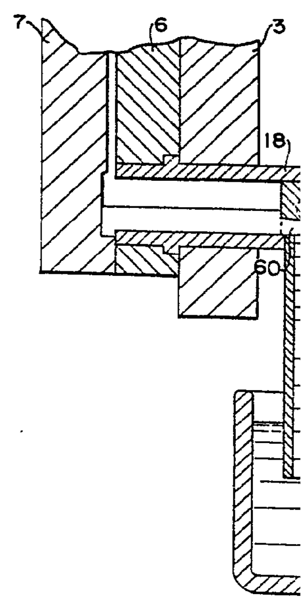
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SHEET 2

FIG. 6

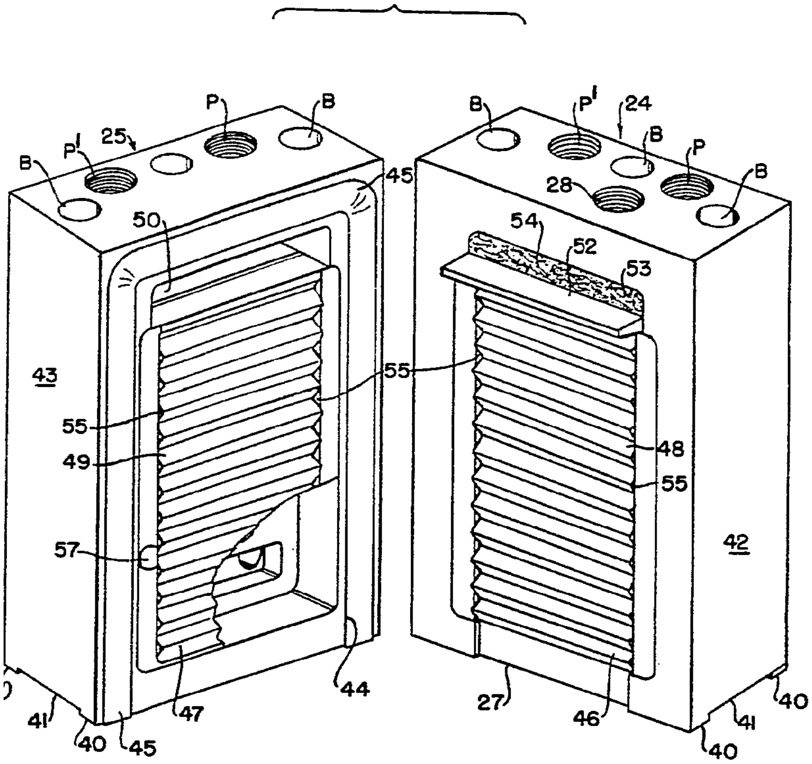


FIG. 7

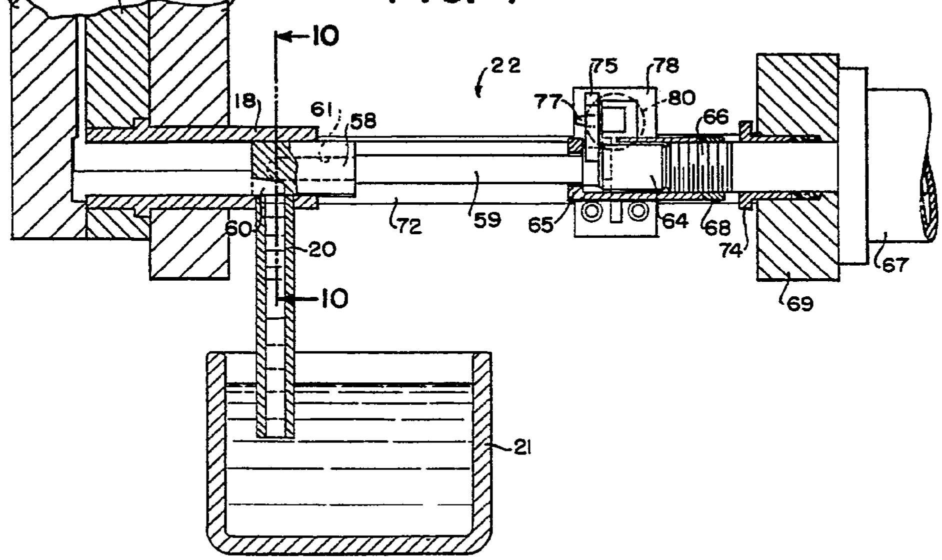

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FIG. 4

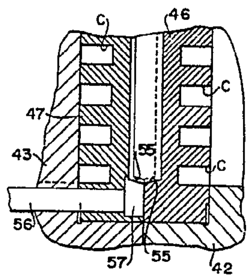


FIG. 5

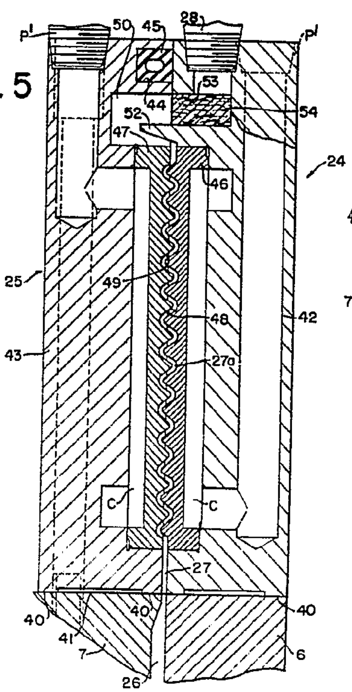


FIG. 6

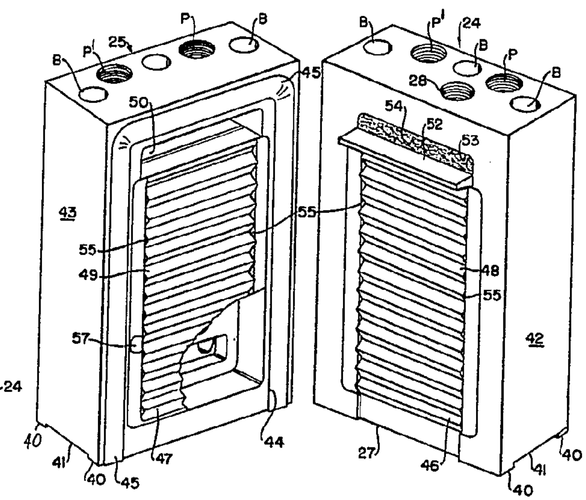


FIG. 7

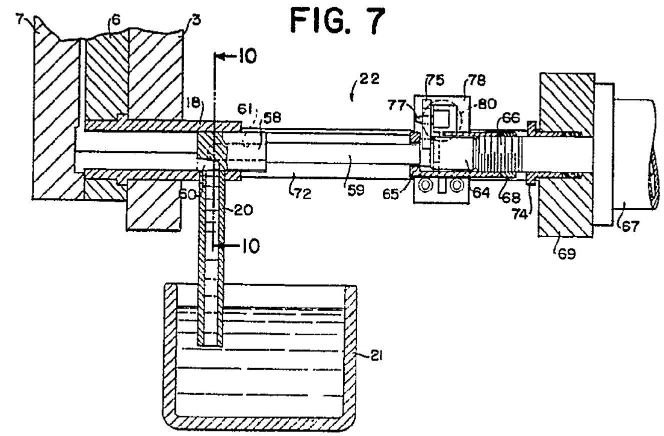


FIG. 8

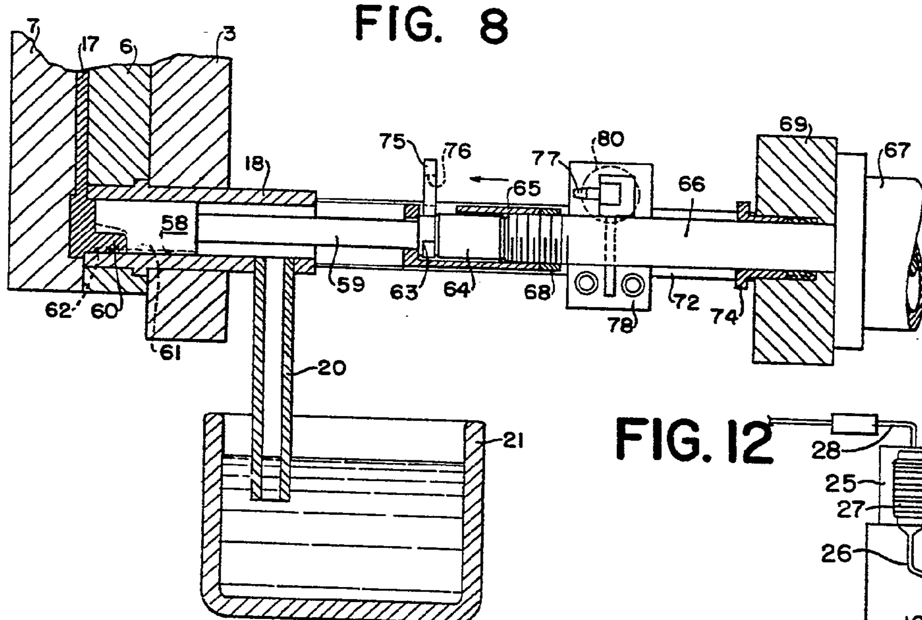



FIG. 12

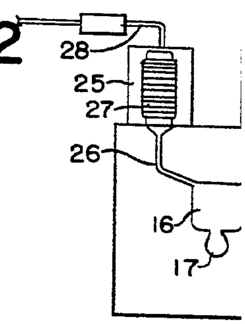



FIG. 10

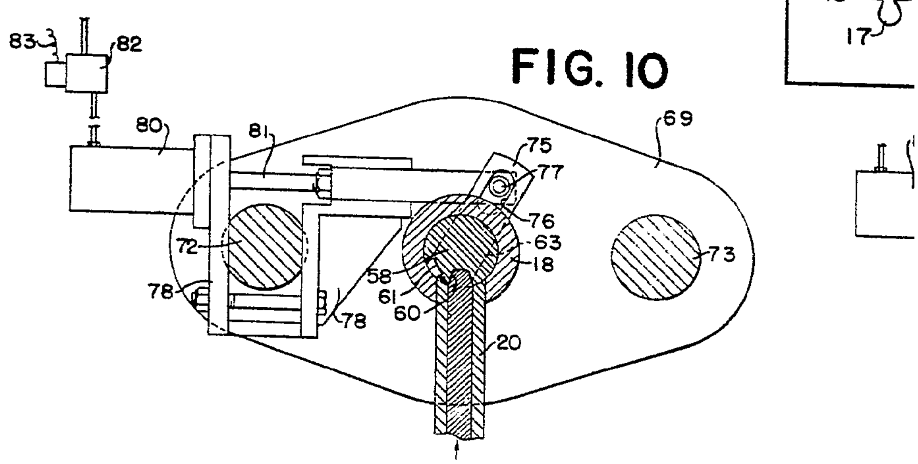
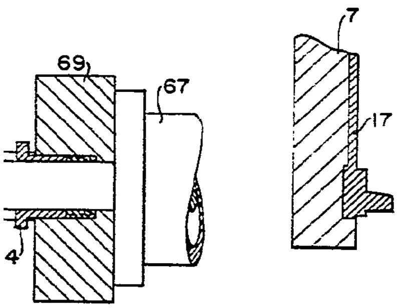
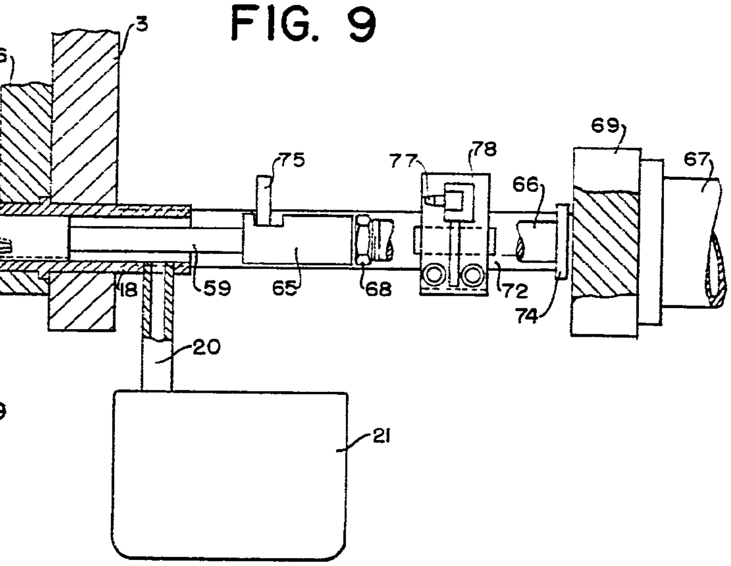


FIG. 9

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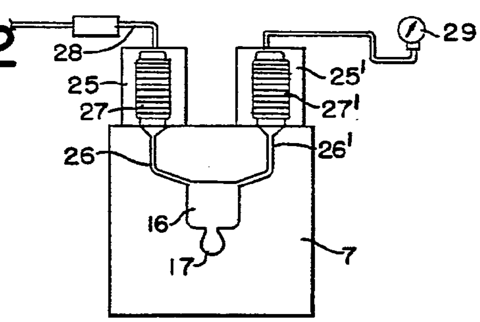


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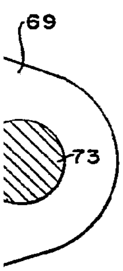
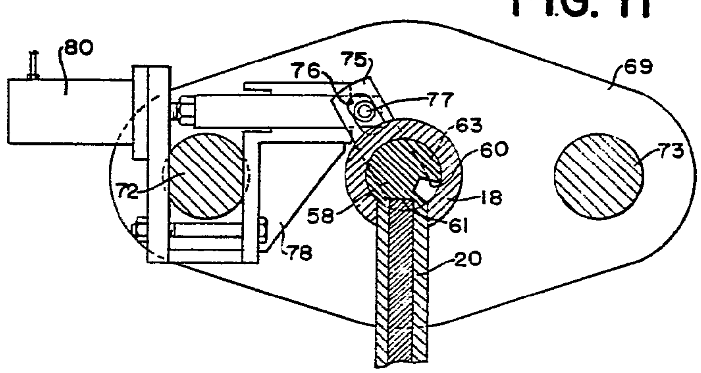



FIG. 11



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SHEET 3

FIG. 8

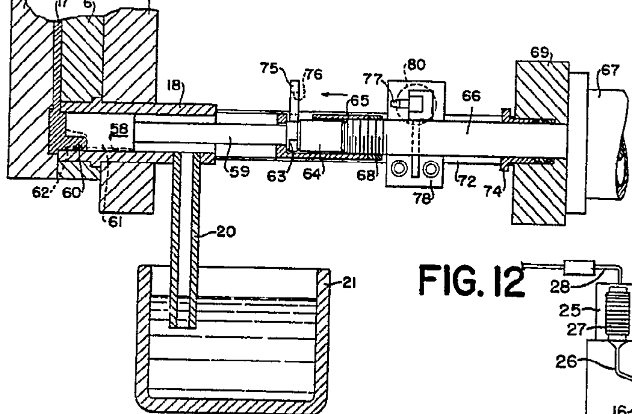


FIG. 9

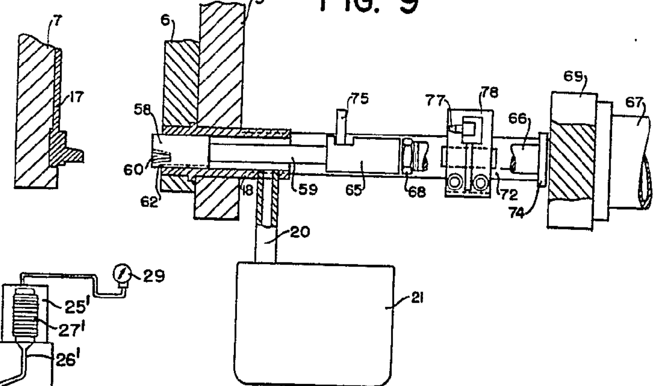


FIG. 12

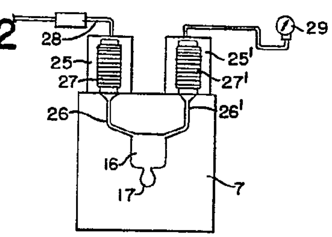


FIG. 10

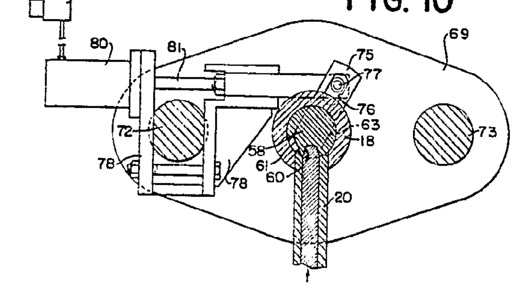


FIG. 11